THE UNSEEN UNIVERSE.

WONDERFUL indeed are the number and the variety of the objects which nature discloses to our view, both in the heavens above, and in the earth beneath. A little reflexion will, however, show us that the things which we can either see, or of which any of our senses can inform us, must nevertheless be almost inconceivably small and unimportant in comparison with those objects in the universe which from one cause or another remain necessarily undiscernible.

It is indeed possible to demonstrate that objects do certainly exist which are not only utterly screened from view, so far as our present resources extend, but which there is not the least reason to anticipate that any future discoveries can introduce to our ken. We might illustrate this proposition from a variety of departments of nature. It is, however, my present purpose to speak only of that unseen universe, which is the most astonishing of all the many astonishing subjects which the astronomer leads us to contemplate.

The whole question as to whether an object shall be visible to us or not is largely a matter of illumination. If the object be bright enough, and if the distance at which it is situated be not too great for the degree of brightness which the object possesses, then that object will generally be visible. We should, however, provide that the sensibility of the retina to the impression of light is not to be reduced by the presence of an undue quantity of diffused light from some other source. A star is generally just visible to us at night by the unaided eye if it possesses that degree of brightness, indicated in the language of the astronomer, when he says that the star is of the sixth magnitude. If that star were moved further away then it

would presently cease to be visible to the unaided eye, though it might still be discerned with the aid of a telescope. The larger the telescope, the greater the depth to which it is able to probe into space. Indeed, it may be said that a star just visible to the unaided eye, would have to be removed to a distance about one thousand times greater, before it had ceased to be visible in the great Lick telescope, or in the great reflector of Lord Rosse at Parsonstown. Were the star to be translated ten thousand times as far as when just visible to the unaided eye, it would apparently be then utterly beyond the reach of any telescope at present existing. It seems, however, possible that even this distance might not be so great as to preclude some stars from recording their impressions in a photographic apparatus when a sufficiently long exposure has been given.

It should, however, be remembered that though in broad daylight stars shine over our head, yet we cannot in general see those stars. The reason is simply that the nerves of the retina are so strongly acted upon by the abundant floods of daylight that the twinkle of even the brightest star fails to produce any recognisable impression. No doubt stars, or at all events, the brighter stars, can be rendered visible in daylight with our telescopes. Supposing, however, that we had lived in perpetual daylight, as we might have done if it had happened that the earth turned round the sun, with the same face always directed thereto, just in the same way as the moon goes round the earth; then, if we had had no telescopes we should never, under ordinary circumstances, have seen the stars. We might indeed have occasionally glimpsed the planet Venus, but with this possible exception we should never have known anything about any other bodies in the universe, save the sun and the moon. All that glorious sidereal spectacle which is disclosed to our gaze at night, would have been utterly unknown. The starry firmament would have formed an invisible universe.

Suppose that a being lived on a world constituted in this manner, then if the sun were to be suddenly eclipsed the whole of that universe, previously invisible and unknown, would have been instantly displayed to the astonished observer. There he would behold for

the first time the Great Bear and Orion, and the other glorious constellations, and sweeping across the sky he would see the marvellous yet delicate glow of the Milky Way. If the being were further told that every single unit in this display of twinkling points of light indicated the existence of a sun in many cases quite as great and as glorious as that sun which was the familiar object in his skies, if he were led to realise that these suns existed in scores of millions, and that each one of them was surrounded by a system of planets, attending upon it in just the same way as the planets revolve around the sun, then indeed he would see that the universe as known to him before the eclipse was nothing compared with that hitherto unseen universe of which he had for the first time been permitted to obtain a brief view. The problem of the invisible universe would indeed be one which would astound his imagination.

It is my object in this article to show that the present state of science forces us to believe that there is around us an invisible universe, which far more widely exceeds even that extended universe which we can see, than does our visible universe exceed that of a being whose celestial knowledge was limited to the recognition of the existence of a sun and a moon. This is indeed one of the most striking conceptions which science has to offer to our contemplation. There are different ways in which it can be presented to us, and I shall try to develop it with such detail as its importance deserves.

Let us suppose that an Australian, born and reared in his country, is at length able to fulfil a long-cherished wish, and visit that ancient home in Great Britain from which so many colonies have sprung. He starts on his voyage, passes through the canal, issues from the Strait of Gibraltar, and presently approaches the shores of Great Britain. But as he does so, it happens to be night—he can see nothing whatever of the coast, the only intimation that he has of his proximity to the long-desired shore is given him by the lighthouses. He sees a bright point; he is told it is the famous Eddystone; he passes on a little further, when another bright point comes into view, indicating the Needles at the Isle of Wight. Then again a twinkling point appears, and he discerns the Forelands.

But, except those lights such as I have named, or other objects of the same description, the voyager can see absolutely nothing of the shores of England. Those beacons, however admirably they may fulfil their functions, do not illumine the objects around them in such a way that they would be visible to the mariner. All the mariner can see, and this is the important point, are the lights themselves; he cannot see, he can get no direct intimation whatever, concerning the objects which lie even in the vicinity of those lights.

Let us suppose that our traveller were so absurd as to refuse to entertain any other impression of England save that which could be derived from his midnight voyage along the coast. To him England would then consist of nothing but the few lights which might be discerned at night from the sea. Everything that land contained, its hills and valleys, its rivers and lakes, its great cities and noble edifices, its wonderful commerce, its teeming myriads of inhabitants, its counties studded with vast manufactories, its abounding life and energy of every description, would be invisible. The whole of that unparalleled collection of human activities and human interests, which are associated with the name of Great Britain, would be utterly unknown to an observer whose opportunities were so limited. This wonderful country could only be represented to his imagination by the few beacons which were visible at night. The visible England, so far as he was concerned, would be a few luminous points, the invisible England would be that marvellous country which those lights were inadequate to illuminate.

This illustration will prepare us for the argument on which I am about to enter. The sun to which we owe so much is no doubt a potent agent of illumination, within the narrow limits, the relatively narrow limits, I ought rather to say, of our solar system. But for purposes of illumination through the length and breadth of the universe, the sun is as utterly inadequate, as a farthing rush light would be for the illumination of a continent. We are apt, quite naturally, to attribute to the sun the possession of a peerless splendor. We must, however, remember that the earth is always comparatively so close to the sun, as to receive abundantly of its radiation, and occupying that position we can enjoy light enough, and

heat enough, to supply all our wants. These services, however, the sun would not be able to render to us, did it not happen that our globe was so close to the source of beneficence. How slender must be the solar effect in illuminating or warming the universe generally, may be inferred from the well-known fact, that many of the bright stars, for example, Sirius or Arcturus, are intrinsically far more brilliant than the sun, but yet how feeble is the twinkle which they can transmit to our point of view. No doubt any objects which may lie in the immediate vicinity of Sirius or of Arcturus might derive from either of those bodies, an illumination quite as splendid, or even far more splendid than that which is supplied to the earth by the proximity of the sun. But sun and stars alike are equally ineffective as illuminating agents, when the length and breadth of the universe are considered.

When, therefore, we raise our eyes to the sidereal heavens, we are to some extent in the same condition as the traveller whom we have supposed to reach the shores of England at night. All he can actually see are the luminous beacons, but those beacons have no effective power for the illumination of the surrounding objects, though they themselves are visible. This point being admitted the significance of what is implied by the title of this paper, will at once become apparent. I set aside of course, any reference at present to the planets. They have no light of their own, it is true. They are rendered visible in consequence of the illumination, which, like the earth, they derive from the radiation of the sun. For our present purpose we are, however, considering not the small group known as the solar system consisting of the earth and planets, all these objects are in close proximity to our own sun; but what we are now considering are the stars and other objects sunk into space all round, at distances compared with which the dimensions of the solar system are utterly insignificant.

It is obvious that the traveller we have supposed, would make a most tremendous mistake if he were to conclude that there was nothing whatever in England except a few beacons round the coast. Yet this, it must be observed, is all that he could possibly know of England, if his view of it were obtained at night from the sea, and

if he had no other sources of information. We are very much in the same condition when we look at the sidereal universe. We view it in the dark, in a darkness only rendered more impressive by the numerous beacons twinkling throughout the extent of space. There is no commanding and universally spreading source of light to render celestial objects visible in the same way, as the sun makes terrestrial objects visible here by day. We see on looking into the heavens no more than the celestial beacons. We see only the bright points which are themselves lighted, we cannot discern the objects which having no intrinsic luminosity are unable to appeal to our sense of vision. I do not think that there is in the whole of astronomy a conception more striking than that which is thus suggested. As the coast-lights on our shores are nothing in comparison with the extraordinary variety and multitude of interesting objects in England, which are wholly invisible to the mariner passing at night, so the celestial beacons which we can see are as nothing in comparison with the extraordinary multitude and variety of objects in that invisible universe, which it seems must be forever screened from our view. For every lighthouse which may be counted around the coasts of Great Britain, there are within the circuit of these coasts, thousands of fields, thousands of beautiful trees, there are many lakes and rivers, there are villages, towns, cities, and great numbers of population. So, too, for every one of the visible stars which can be counted in the skies, there must be hundreds or thousands, indeed, there are doubtless millions of other objects, utterly beyond our ken. Of the existence of these unseen objects, and of their nature and properties, we can only occasionally become aware, in a most indirect, indeed, I might say in a most casual manner. Now, indeed, the sublimity of the conception of the unseen universe becomes adequately unfolded. Reflect on the number of luminous stars which the heavens contain, think of the thousands of stars which are visible to the unaided eye, think of the tens of thousands of stars which are visible in small telescopes, think of the hundreds of thousands of stars which are visible in a moderate telescope, and of the abounding millions of stars which are disclosed by our mightiest instruments, or which are represented on our most

sensitive photographic plate. Then remember that each one of these stars is, as it were, a luminous beacon, and that the invisible objects must be incredibly more numerous than the beacons themselves.

In this way we begin to realise that for each body which we see, glowing as a fervent star, there must be thousands or millions of other bodies often as large, often doubtless a great deal larger than the luminous stars. We do not see the great majority of celestial objects from the simple fact that they do not, generally speaking, possess a temperature sufficient to make them glow in the manner necessary for vision. If, indeed, the mind is baffled in the attempt to comprehend the scale of the universe which contains, as we know it does, millions of stars, many of them as bright and as glorious as the sun, what are we now to think when it is brought before us that each one of these stars is itself only one of millions of objects, which happens by the fortuitous circumstance of temperature to be rendered visible?

We may illustrate the line of reasoning that we have followed in another way. We have often heard of those beautiful fire-flies, which, in clouds of dancing points of light, form a striking feature after the night has fallen in certain warm latitudes. Suppose that some celestial being who was taking a survey of our earth at night, when all artificial sources of illumination were absent, was trying to obtain some notion as to the nature of the animated inhabitants of the earth. His survey being made in the darkness would necessarily preclude him from being able to perceive the greater number of living forms. The huge bulk of the elephant, or of the rhinoceros, must pass unnoticed, the stately giraffe would not be visible, lions, tigers, and bears, would be as invisible as cows or sheep. Birds of every size and of every hue must be utterly unknown to an observer so circumstanced, and still more would innumerable hosts of minor creatures remain undetected. Such an observer might in fact hastily come to the conclusion that there was, indeed, no life whatever on this earth. Suppose, however, that he made a very minute inspection, he might discern here and there the little gleam of light from a glow-worm on a mossy bank, here and

there he might detect the indications of phosphorescent sparks in the sea water, here and there he would be gratified by the sight of a cloud of fire-flies dancing about in the darkness. If this celestial being, having duly noticed these things, having counted the number of glow-worm twinkles that he could see, and having depicted or measured the phosphorescent points and the clusters of fire-flies, were straightway to rise up and say that now he knew all about the distribution of life on this earth, how greatly, indeed, would he have been mistaken. No doubt it may be admitted that he would have seen a very large number of creatures. The number of fire-flies in their clustering millions may really rival, for aught I can tell, the number of stars in the Milky Way, or that of the minute stellar points in the deep background of the firmament. But how ludicrously incomplete would be the knowledge of the natural history of this earth, which could possibly be obtained by one whose only opportunity for observing the life on our globe was obtained under the limitations we have sketched. All the more important forms of life would be quite unknown to such an observer, he would really have perceived only an infinitesimal part of the total life on the globe. Those creatures alone would be visible to him, which possessed intrinsic luminosity. The creatures so endowed form it may be an interesting, but certainly only a most insignificant part of animated nature.

In like manner, when we raise our eyes to the skies, we see it is true, a myriad of glittering gems, but these are only the glow-worms and the fire-flies of the universe. That is to say, they are the objects which are visible in virtue of the light which they themselves dispense, while objects which are not endowed with the capacity for radiating luminosity must be as invisible to us, as the birds and beasts on the earth would be to the spectator whom we have just been considering. There can, however, be little or no reason for doubting that the invisible objects in the universe exceed those which are visible in consequence of their luminosity, in a proportion quite as remarkable as that in which the ordinary animals devoid of luminosity exceed those which possess phosphorescent qualities. We must again affirm that the only objects which can be seen by us

in the skies, (setting aside the planets and a few other bodies in the solar system,) are those objects which are self-luminous in consequence of their intensely high temperature. A star is a mass of matter heated to such an extent that its effulgence is perceived far and wide. It must, however, be borne in mind, that for a portion of matter to be heated so highly, is always a more or less exceptional phenomenon. From the very nature of the case, the condition it implies is a temporary one. We find little difficulty in conceiving the eternal existence of matter at a temperature no greater than that of the surrounding space, but when a piece of matter, solid, liquid, or gaseous is heated to incandescence, it is in the very nature of things that this condition is but transient. The high temperature may last, no doubt, as the high temperature of the sun has lasted, for millions of years. It cannot, however, be perpetual, and when at last that portion of matter sinks again to the temperature of space, there it may remain to all eternity unless in so far as by the chapter of accidents it may be again kindled into temporary luminosity. It thus appears that the normal and ordinary state of the matter in the universe is to be cold, non-luminous, and therefore utterly invisible to us. Those portions of matter which are at any moment luminous must certainly be very greatly inferior in numbers to those which are at the same time in the normal condition. Every line of reasoning demonstrates that the material universe, so far as it is visible, can only be an almost inconceivably small fragment of that unseen universe, which, from not possessing the necessary quality of luminosity, is effectually shrouded from our view.

The conclusion to which we are thus led is, indeed, a remarkable one. Think first of the visible stars in their units, in their constellations, and in their myriads, so vast that the imagination of man fails to realise their number. But a much mightier effort would, however, be necessary if we would seek to form a truly comprehensive estimate of the contents of the universe. We are to reflect that all objects which we can see constitute in all probability not one thousandth, perhaps not one millionth, part of the material heavens. We are to reflect that each one of those suns which we

find glowing in the depths of space, is only one out of an untold number of other bodies, many of which are quite as large and many of which are very much larger. Any object that we do see is able to attract our attention merely because of the accidental circumstances that it happens at this particular epoch to be glowing with luminosity. It is therefore essential for any one who desires to obtain a due conception of the scheme of things celestial, to recognise that the glorious universe which we can behold is as nothing compared with that material system of which we can never become adequately informed, and which we call the unseen universe.

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